

Analyzing and Visualizing Precipitation and Soil Moisture in ArcGIS

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NASA Goddard Earth Science Data and
Information Services Center

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Objective

- Introduce hydrological data available from the NASA Goddard Earth Science Data and Information Services Center (GES DISC)
- Demonstrate the use of GES DISC data in ArcGIS to visualize and analyze drought, flood, and climate/vegetation relationships.

The Uniqueness of NASA GES DISC Data

- GES DISC is one of twelve NASA Science Mission Directorate Data Centers.
- GES DISC hosts thousands parameters with high spatiotemporal resolutions and readily usable in ArcGIS, particularly:
 - Precipitation and hydrology, including soil moisture
 - Land Data Assimilation System data (LDAS)
 - Modern Era Retrospective-Analysis for Research and Applications data assimilation data (MERRA)
 - Various other multi-mission supported project data through value added services (e.g., water quality, air quality)

Characteristics of GES DISC Hydrology Data

- Remote sensing, in-situ, modeling, and forecast
- Multiple spatiotemporal resolutions:
 - Half-hourly, 3-hourly, daily, monthly satellite measurements
 - Hourly modeled products
 - Monthly ground observation archives
 - Composite Climatology (yearly, monthly)
 - Near real-time products
 - Global grids (raster) with spatial resolution up to 10-km
 - Higher resolution swath (feature points) data (e.g., 4-km)

Methods and Stories Told

- Methods:
 - Anomalies derived from time series data
 - Visualize time series using ArcMap time slider
 - Correlation analysis
- Events
 - The ongoing California drought
 - The 2010-2011 East Africa drought
 - The 2015 south India flood

Data Used

- 10-km resolution precipitation from the Global Precipitation Measurement (GPM) Mission
- 25-km resolution precipitation from the Tropical Rainfall Measurement Mission (TRMM)
- 10-km resolution root zone soil moisture from the North America Land Data Assimilation System (NLDAS)
- 10-/25-km soil moisture from the Land Parameter Retrieve Model (LPRM)
- 5-km resolution NDVI from MODIS
- 0.625x1-deg resolution MERRA2

Visualizing and Analyzing Time Series Data Anomaly in ArcGIS

- GES DISC data are available in various GIS formats, including NetCDF within which a time dimension can be defined.
- Time enabled NetCDF data can be easily visualized in ArcGIS.
- A common method to find temporal feature is using standardized anomaly:

$$A=(X-X_m)/X_s$$

A: standardized anomaly,

X_m : long term mean (for a calendar month, year, etc)

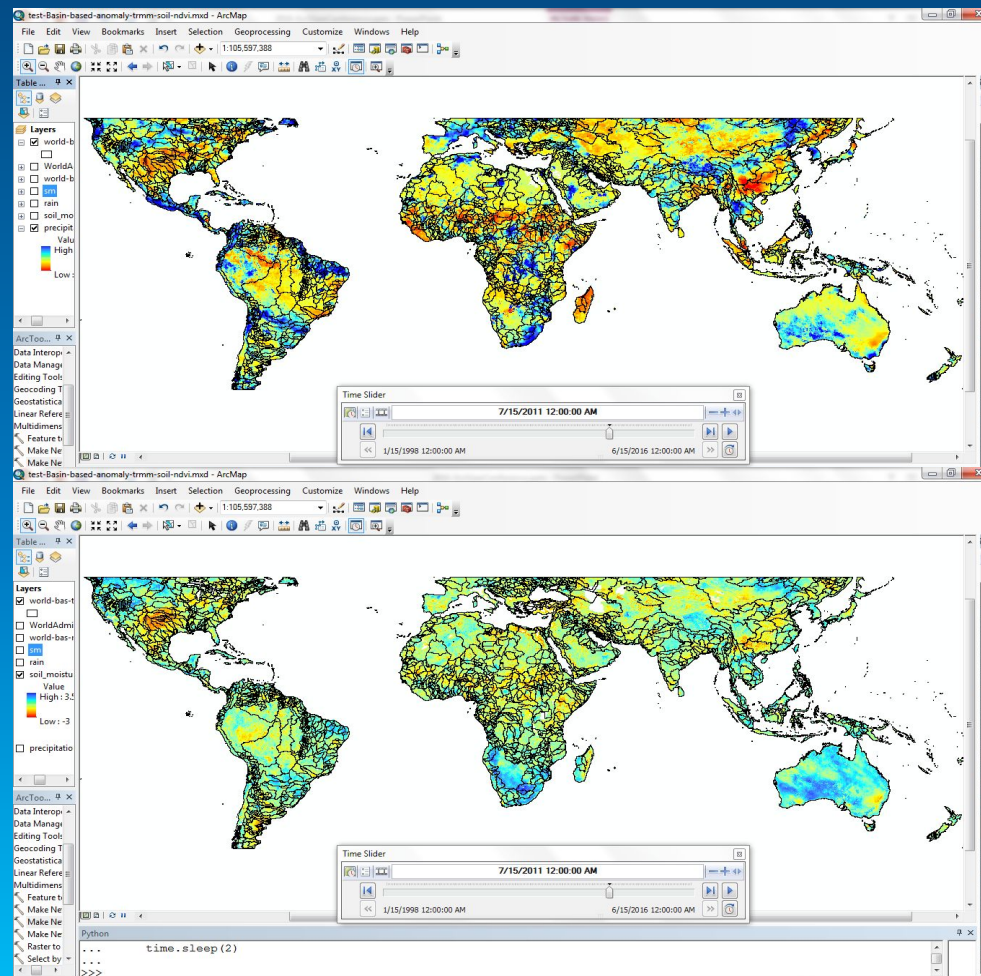
X_s : standard deviation to the long term mean

X: measurement for a particular period (month, year, etc)

TRMM Precipitation and LPRM Soil Moisture

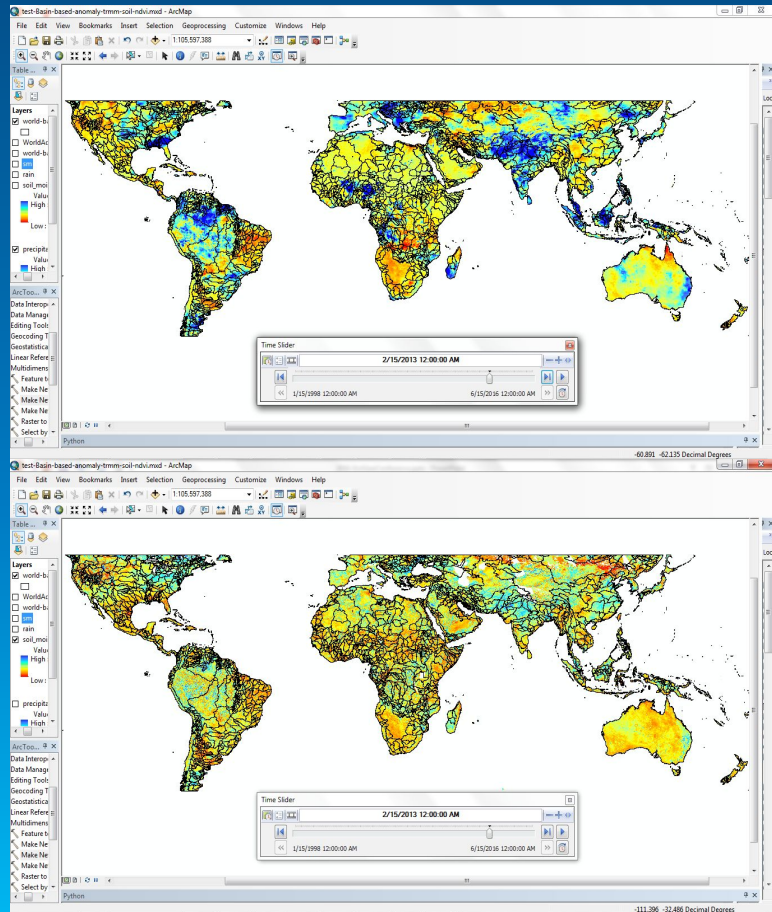
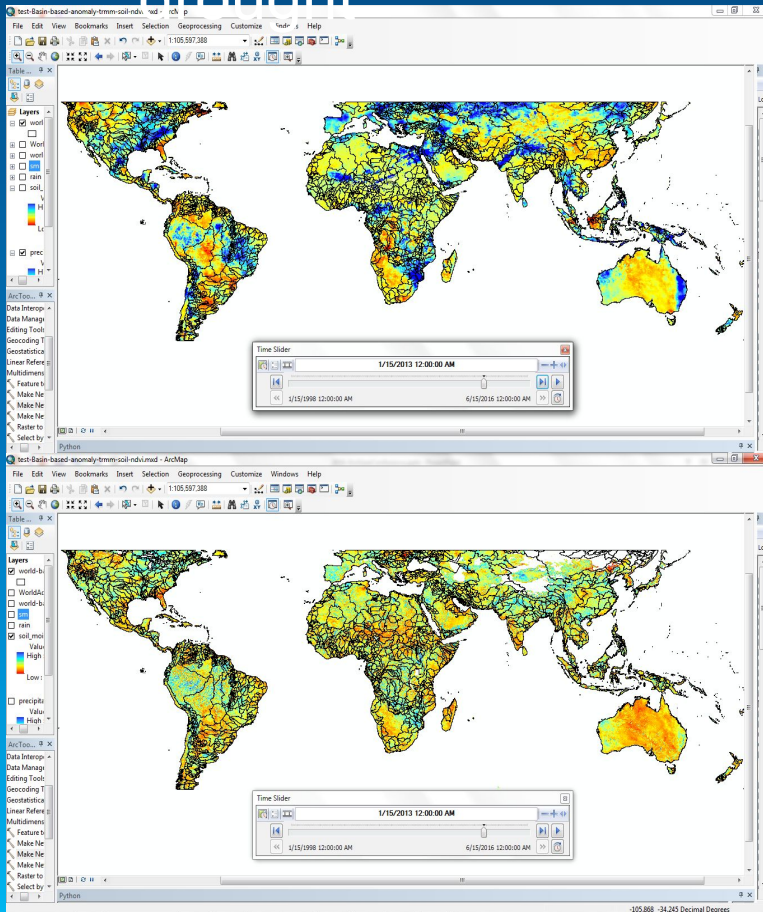
Negative anomaly in east Africa:

The 2010-2011 east Africa drought

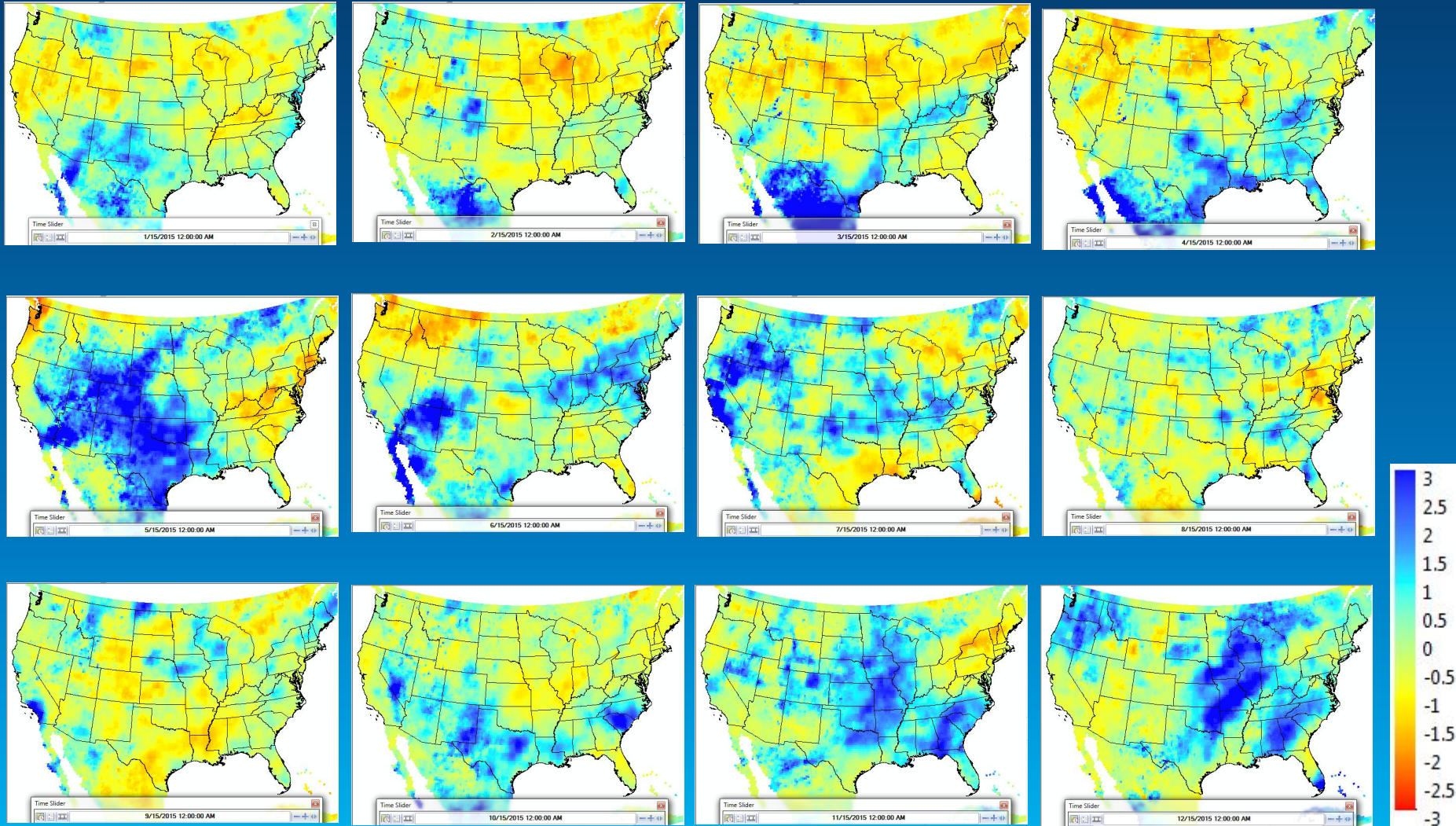


TRMM Precipitation and LPRM Soil Moisture

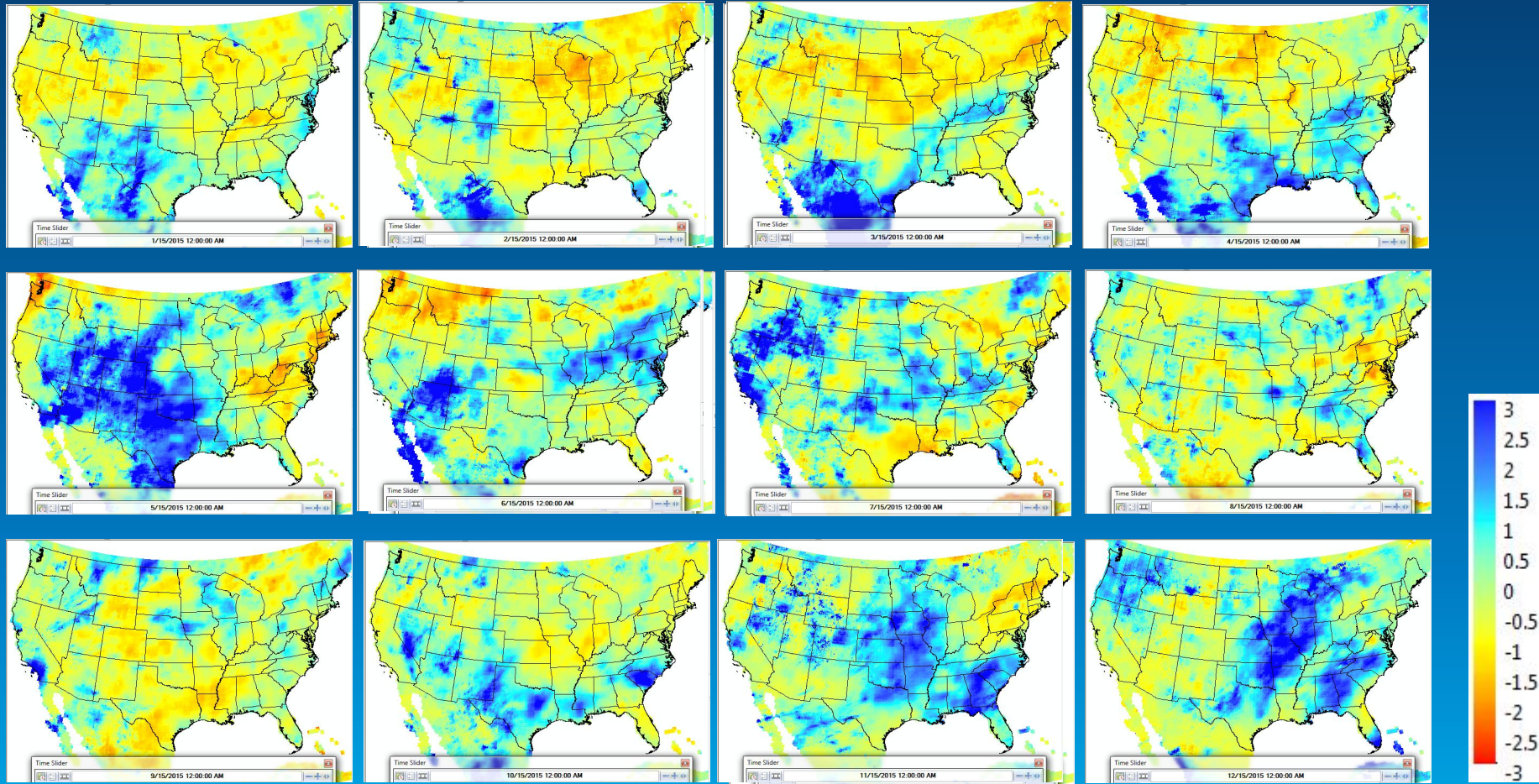
Negative anomaly in CA:
the on-going California
drought



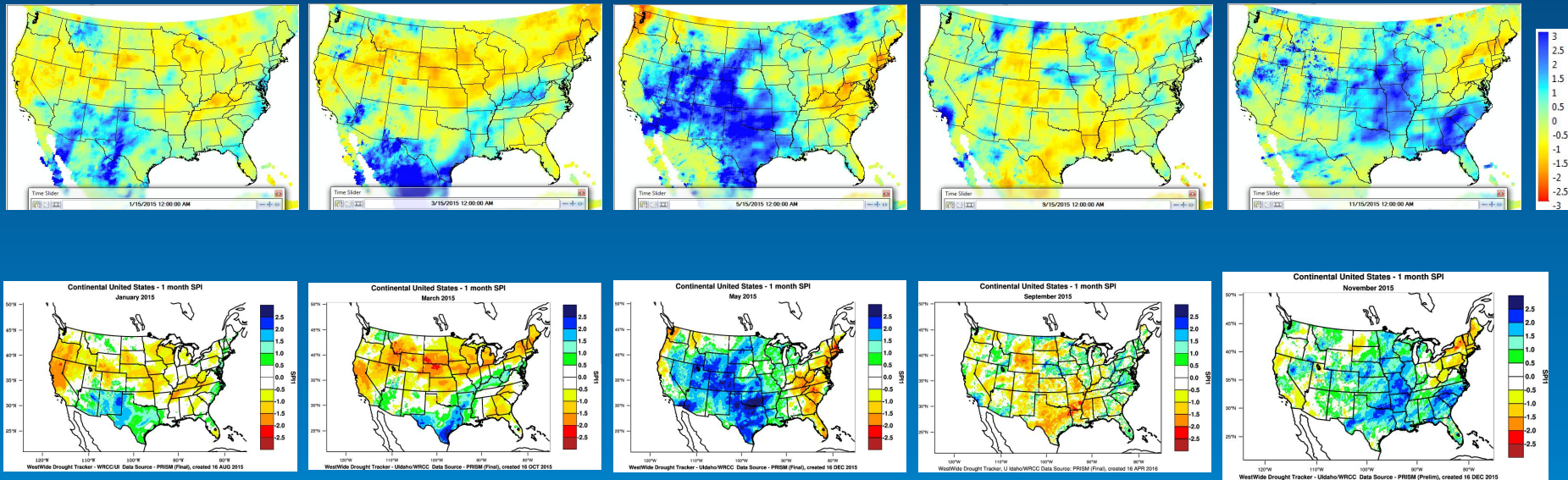
TRMM Precipitation Anomaly - 2015



GPM Precipitation Anomaly - 2015



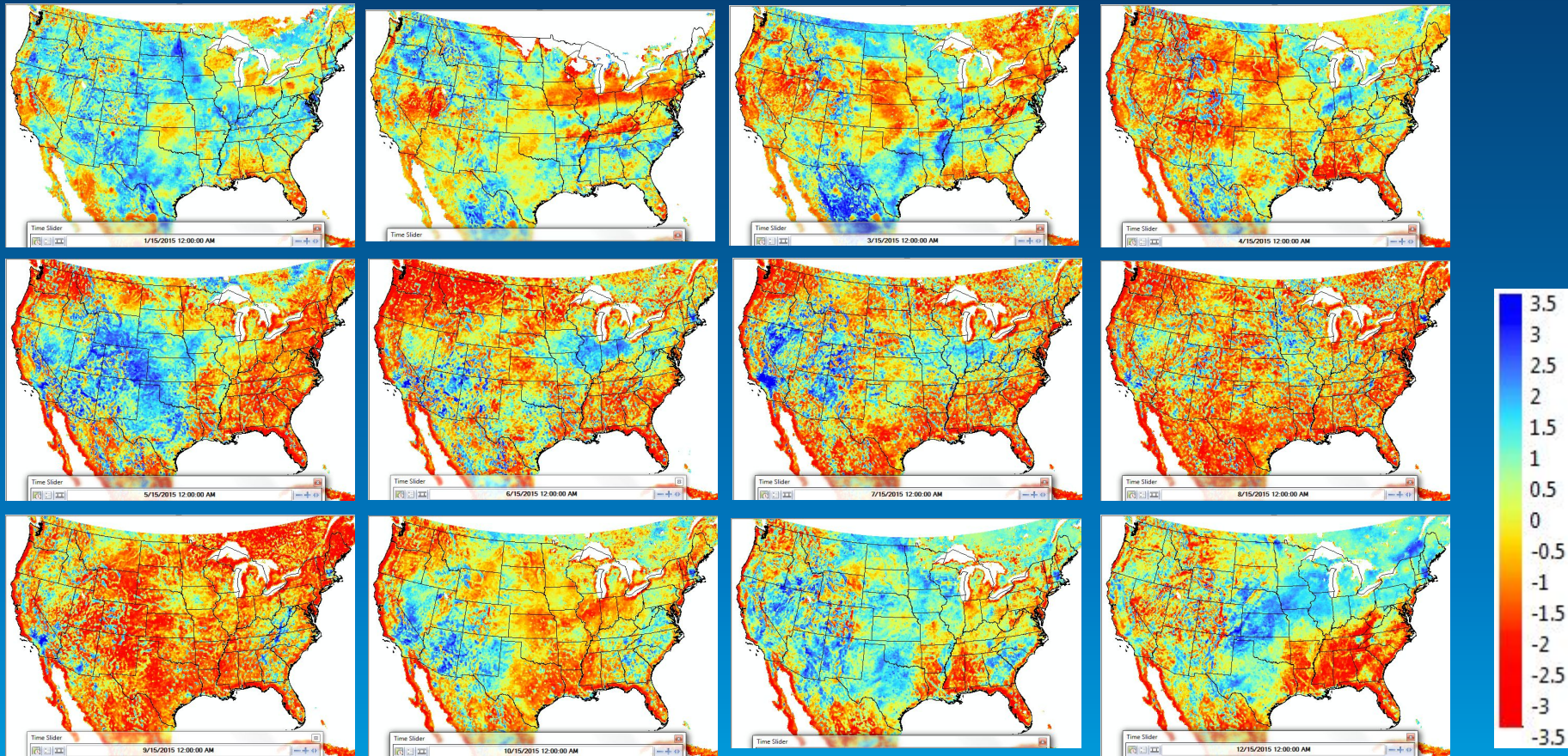
GPM Precipitation Anomaly vs SPI



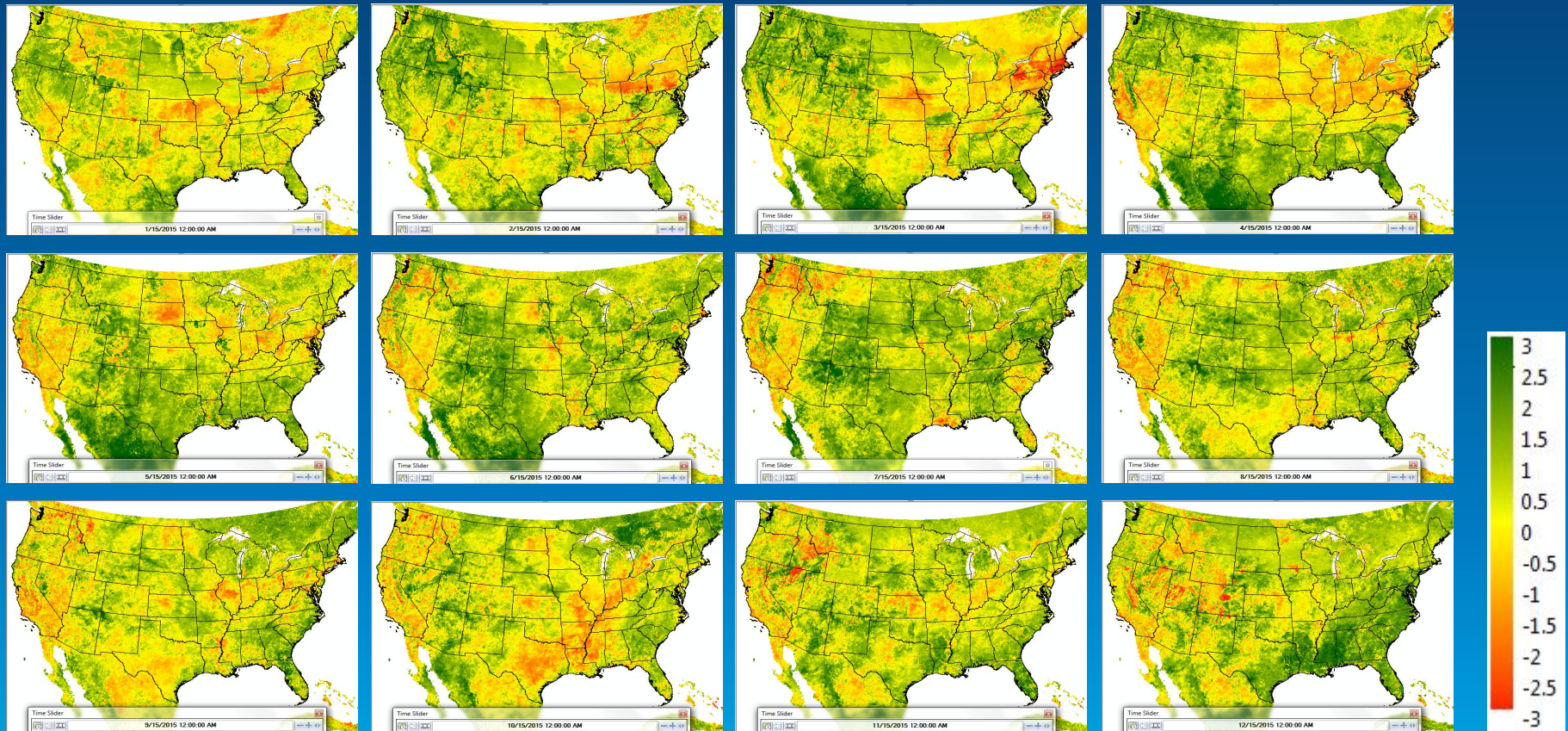
Acknowledgement:

SPI images are screen-copied from the WestWide Drought Tracker Web site of the Western Regional Climate Center: <http://www.wrcc.dri.edu/wwdt/archive.php>

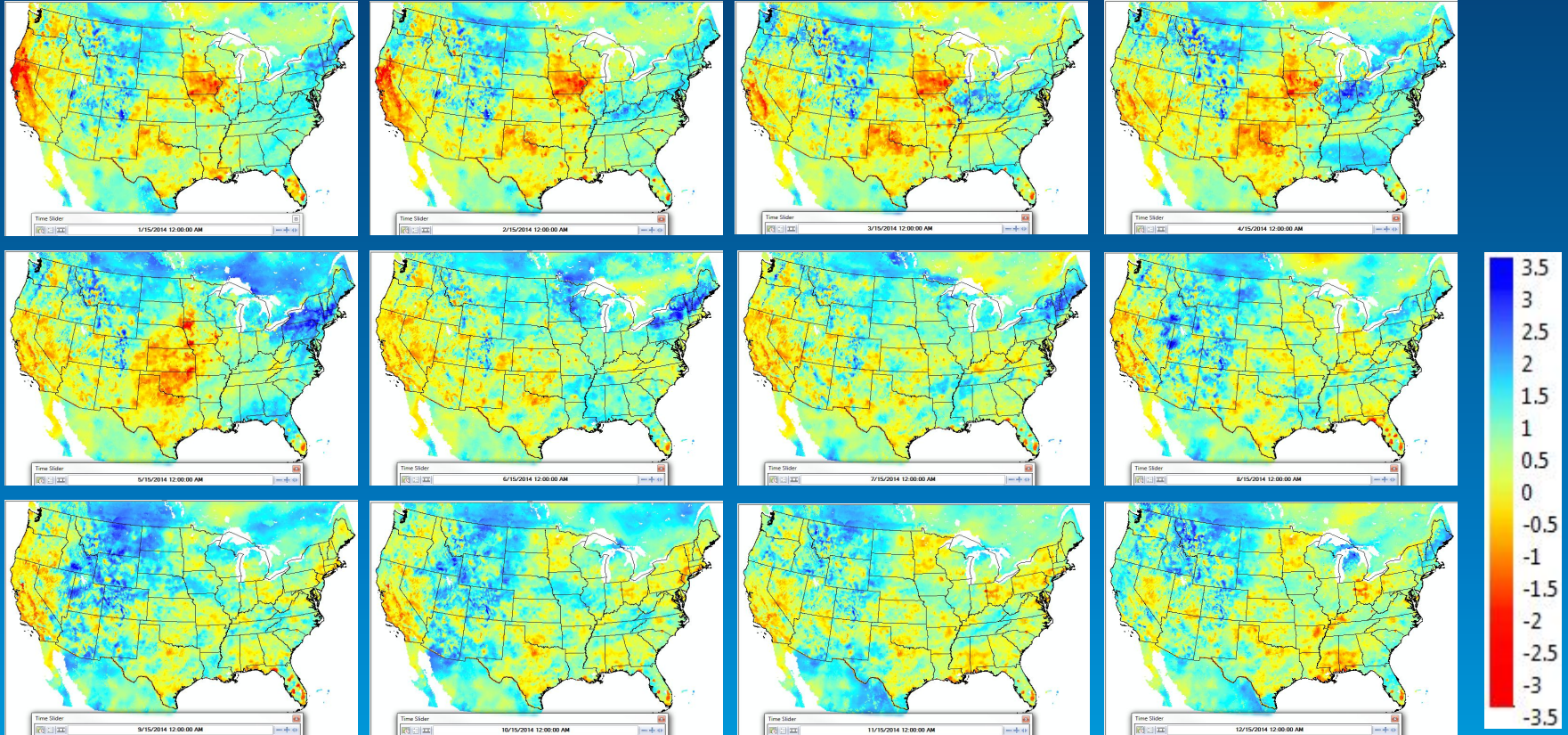
LPRM Soil Moisture Anomaly - 2015



MODIS NDVI Anomaly - 2015

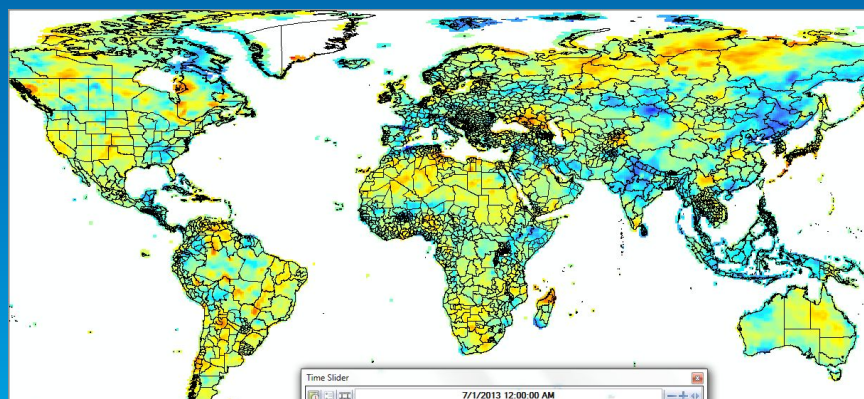
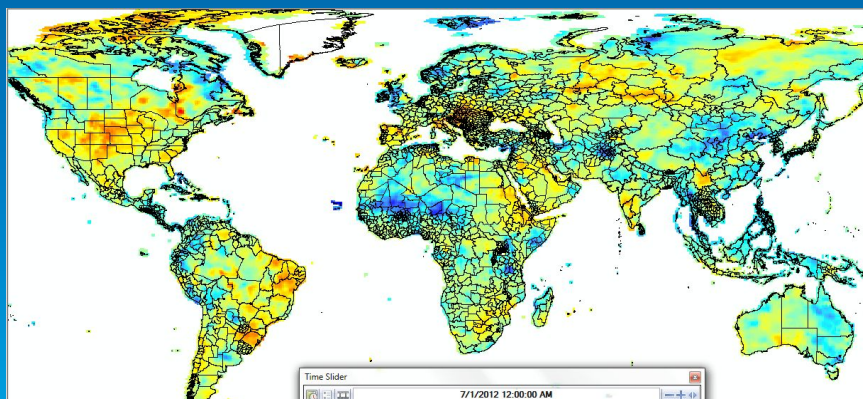
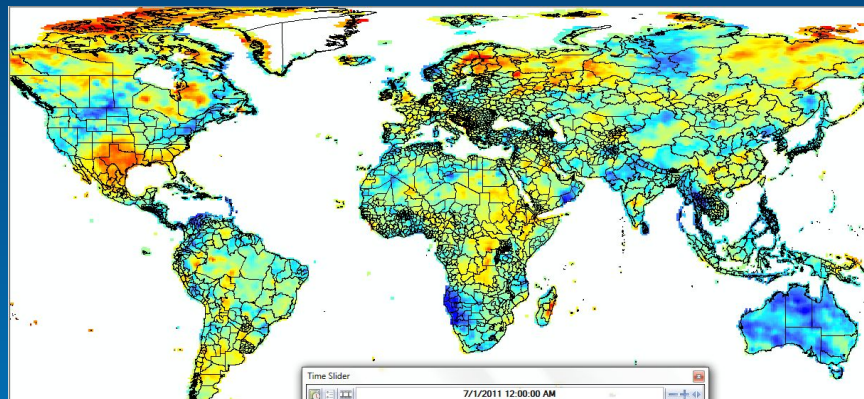
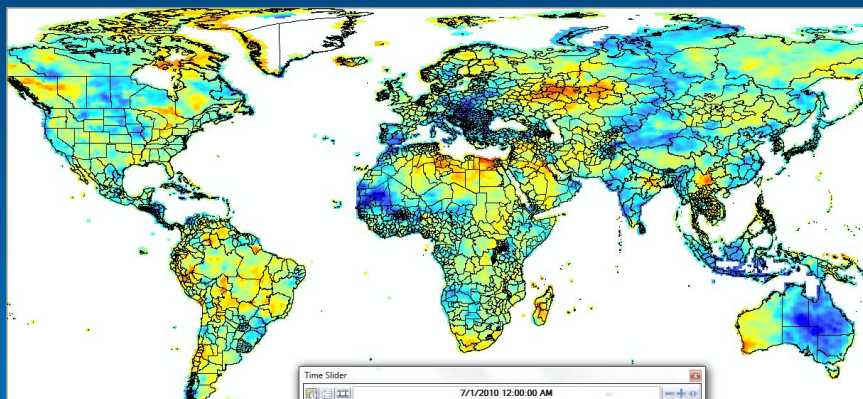


NLDAS Root Zone Soil Moisture



MERRA2 Surface Wetness

Yearly anomaly based on 1980-2015 monthly data



Water Basin-based Analysis

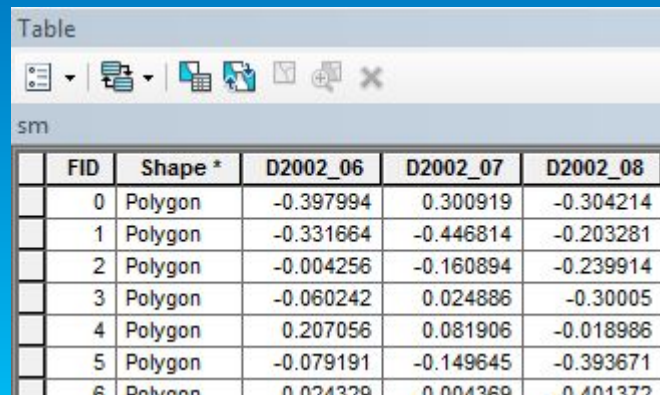
- Raster data often analyzed with point and polygon features
- Zonal statistics analysis in level 3 world water basins
- Visualize time series feature data
 - Import zonal statistical table into polygon shapefile's dbf
 - Simple python scripts

Visualize the zonal anomaly time series with simple script

```
sm_lyr.visible=0
rain_lyr.visible = 1
start_year = 1998
end_year = 2016
for year in range(start_year,end_year):
    for month in range (1,13):
        rain_lyr.symbology.valueField =
            'D'+'%4d'%(year)+'_'+'%02d'%(month)
        rain_lyr.symbology.reclassify()
        arcpy.RefreshActiveView()
        time.sleep(2)
```

```
def rain(date):
    rain_lyr.symbology.valueField = date
    rain_lyr.symbology.reclassify()
    rain_lyr.visible=1
    sm_lyr.visible=0
    arcpy.RefreshActiveView()
```

rain('2016_01')

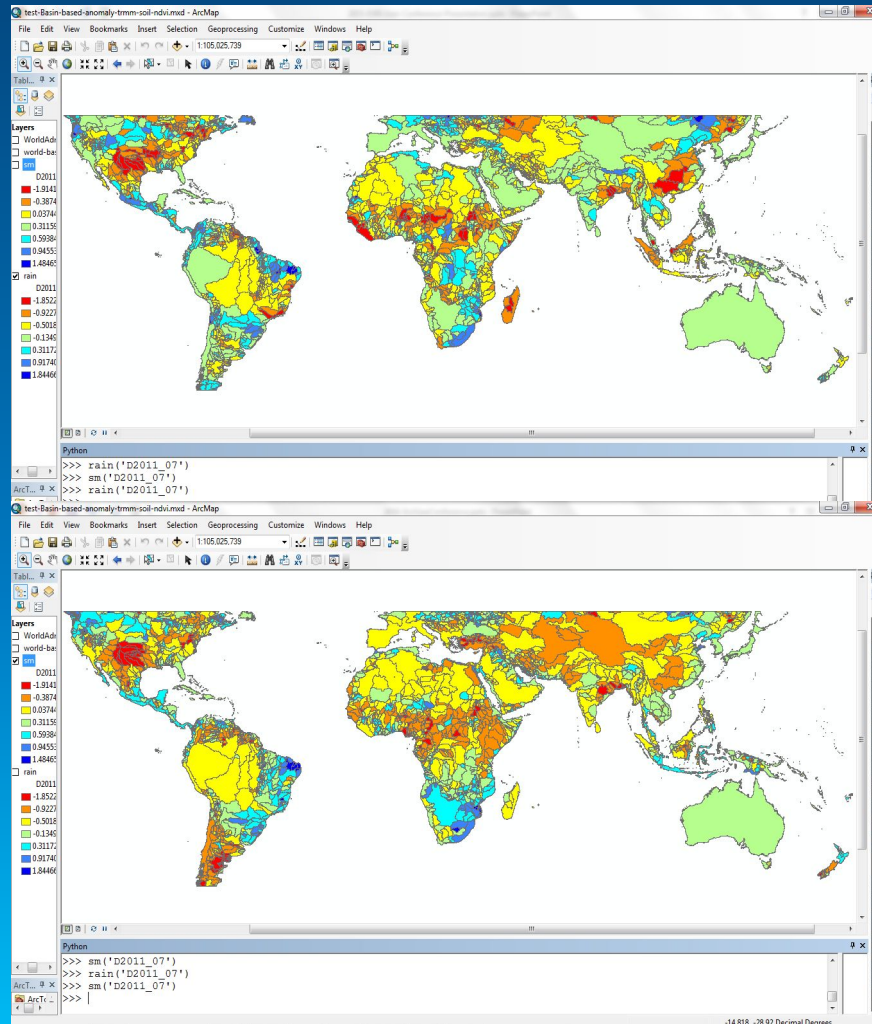


The screenshot shows a table window titled 'Table' with a toolbar. The table is named 'sm' and contains 6 rows of data. The columns are FID, Shape *, D2002_06, D2002_07, and D2002_08. The data represents zonal anomalies for the first month of 2016.

	FID	Shape *	D2002_06	D2002_07	D2002_08
	0	Polygon	-0.397994	0.300919	-0.304214
	1	Polygon	-0.331664	-0.446814	-0.203281
	2	Polygon	-0.004256	-0.160894	-0.239914
	3	Polygon	-0.060242	0.024886	-0.30005
	4	Polygon	0.207056	0.081906	-0.018986
	5	Polygon	-0.079191	-0.149645	-0.393671
	6	Polygon	0.024329	-0.004369	-0.401372

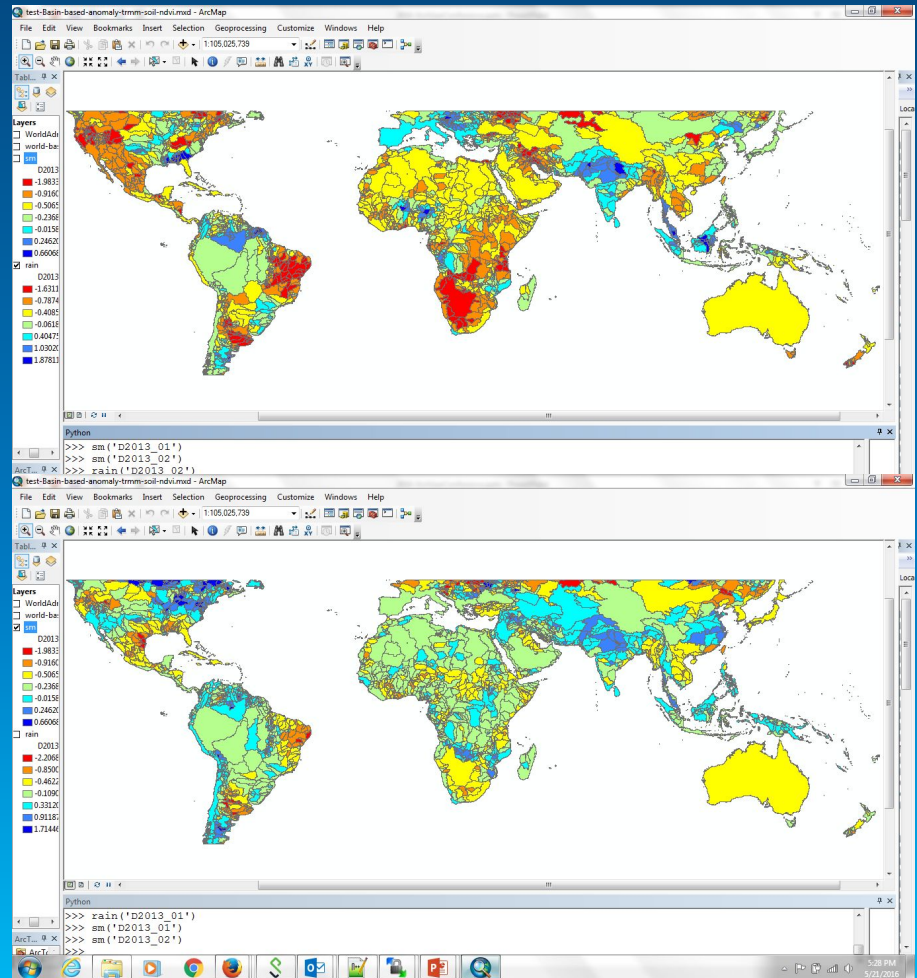
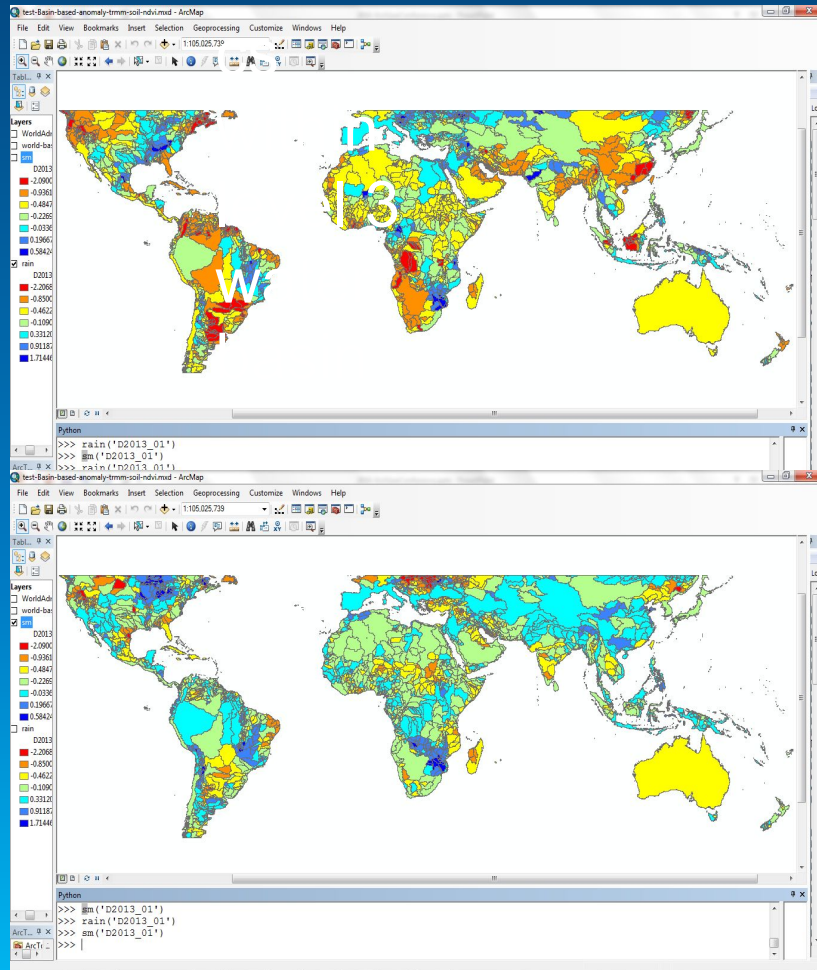
TRMM Precipitation and LPRM Soil Moisture Anomalies

Zonal statistics within level 3 water basin



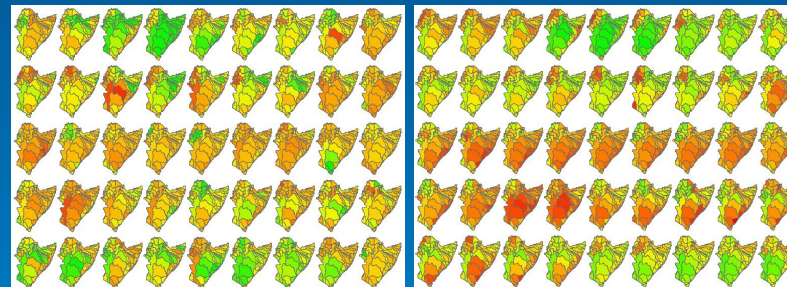
TRMM Precipitation and LPRM Soil Moisture Anomalies

Zonal
statisti



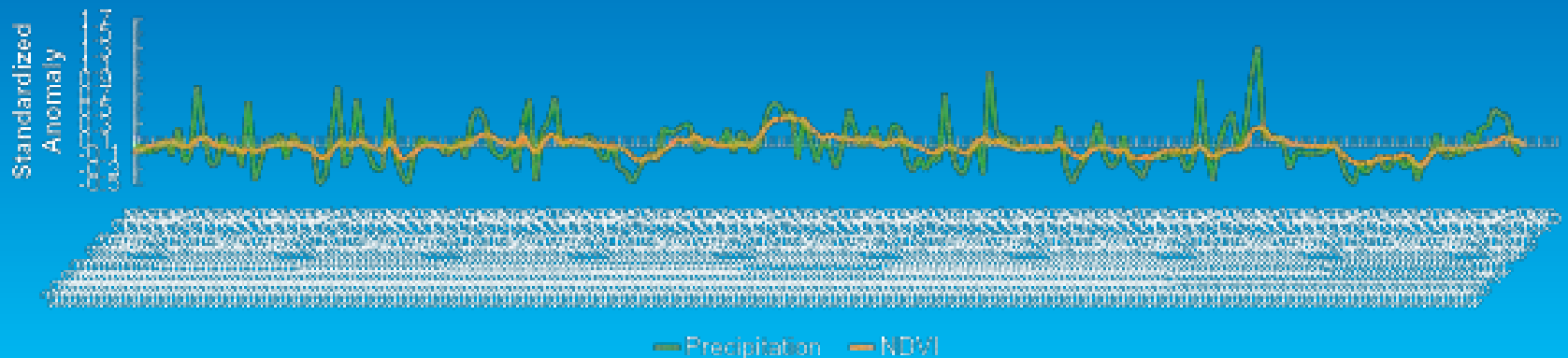
Relationship between Precipitation and Vegetation: East Africa Drought

- 16-day composites of precipitation and NDVI from Jan. 2010 to Dec. 2011
- All water basins exhibits statistically significant precipitation/NDVI correlation when one or two time period lags are applied to NDVI data.



TRMM precipitation

MODIS NDVI

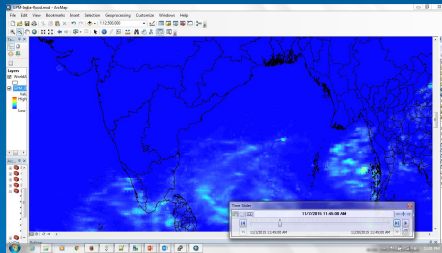


High Spatiotemporal GPM Data for Storm and Flood Visualization and Analysis

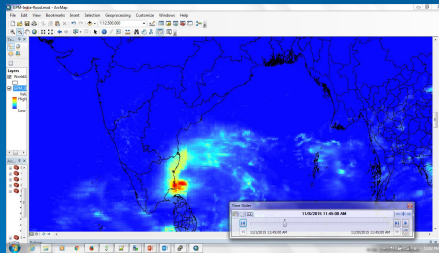
South India Flood – 2015 Northeast Monsoon

Daily GPM Precipitation, Nov. 7-10 and 14-17

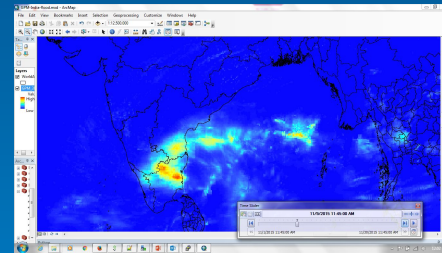
Nov. 7



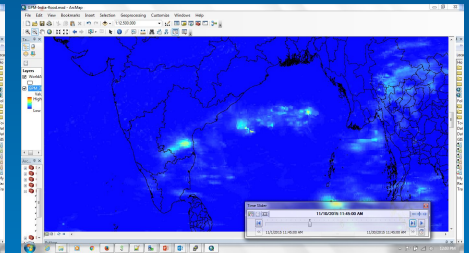
Nov. 8



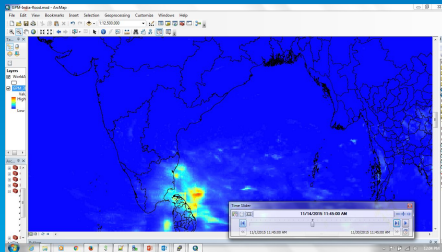
Nov. 9



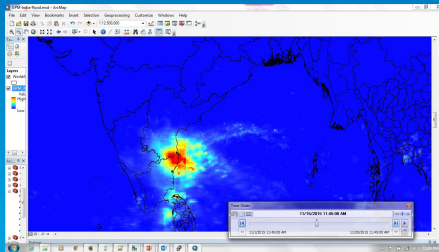
Nov. 10



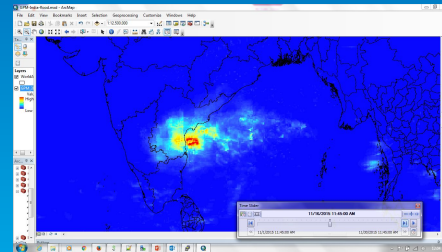
Nov. 14



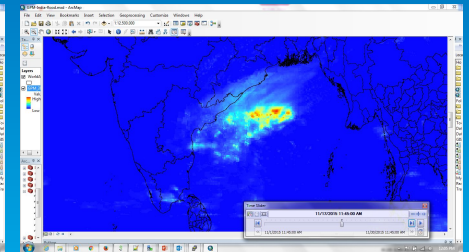
Nov. 15



Nov. 16

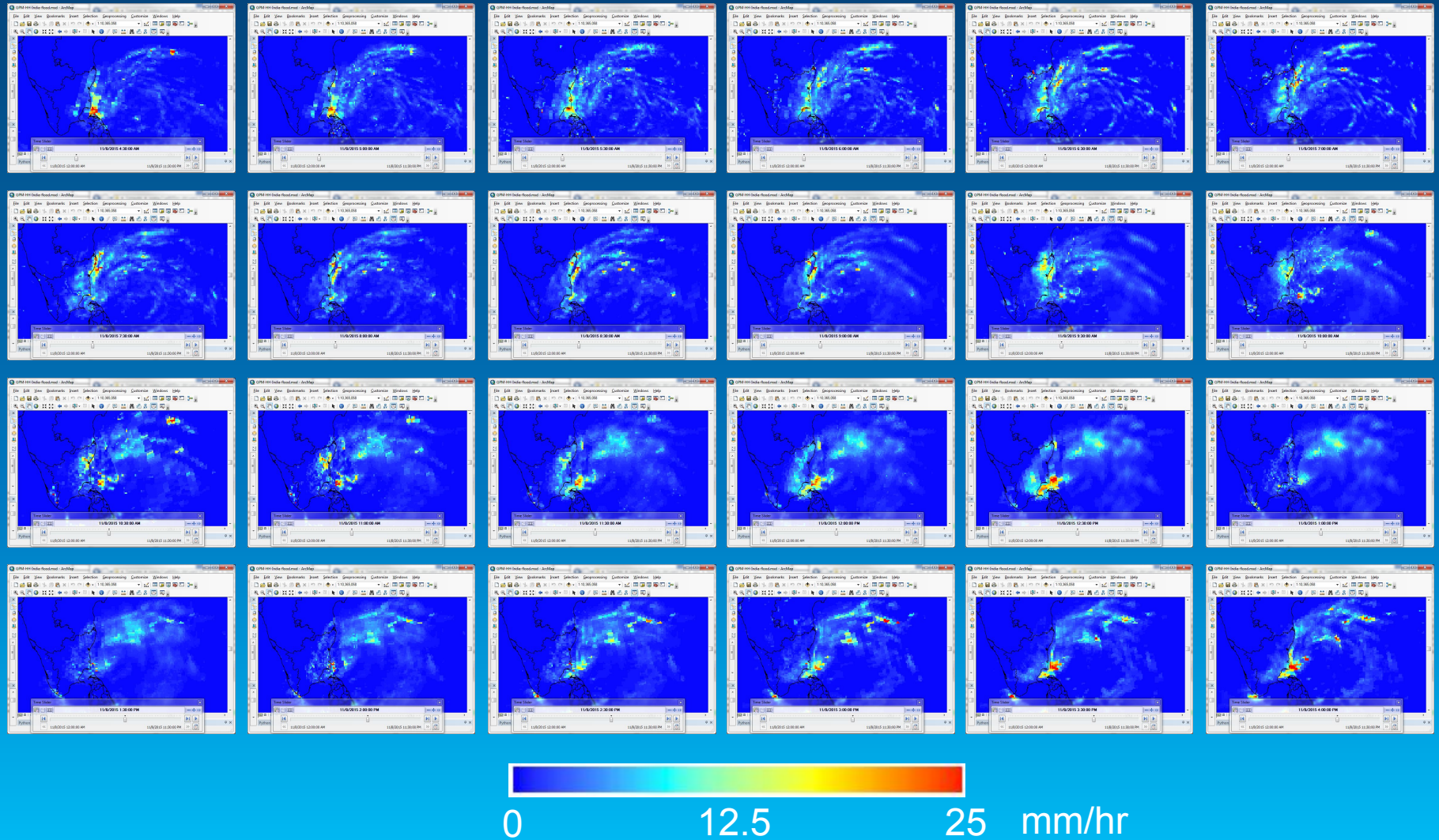


Nov. 17



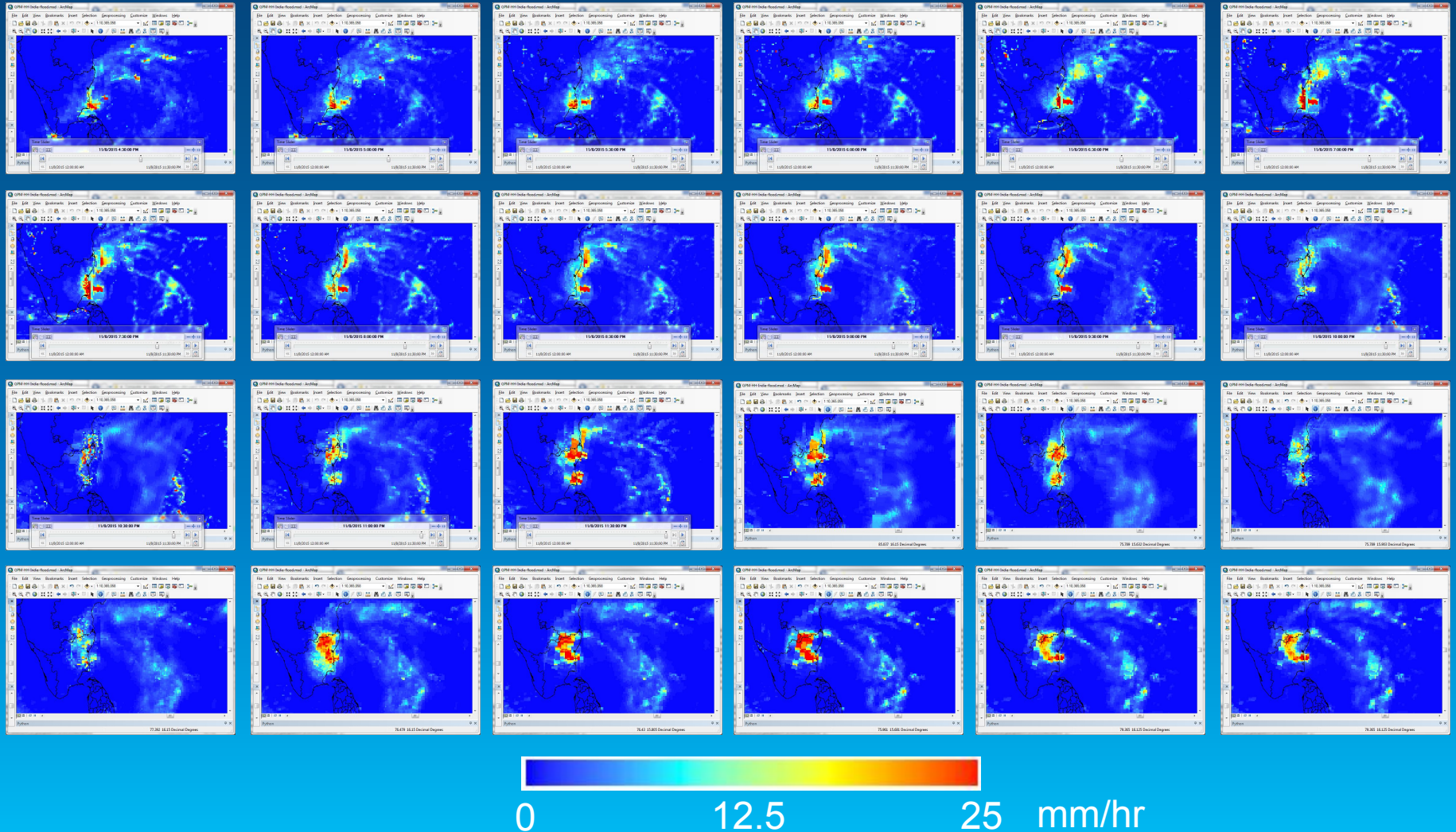
South India Flood – 2015 Northeast Monsoon

Half Hourly GPM Precipitation, 4:30am – 4:00pm November 8.



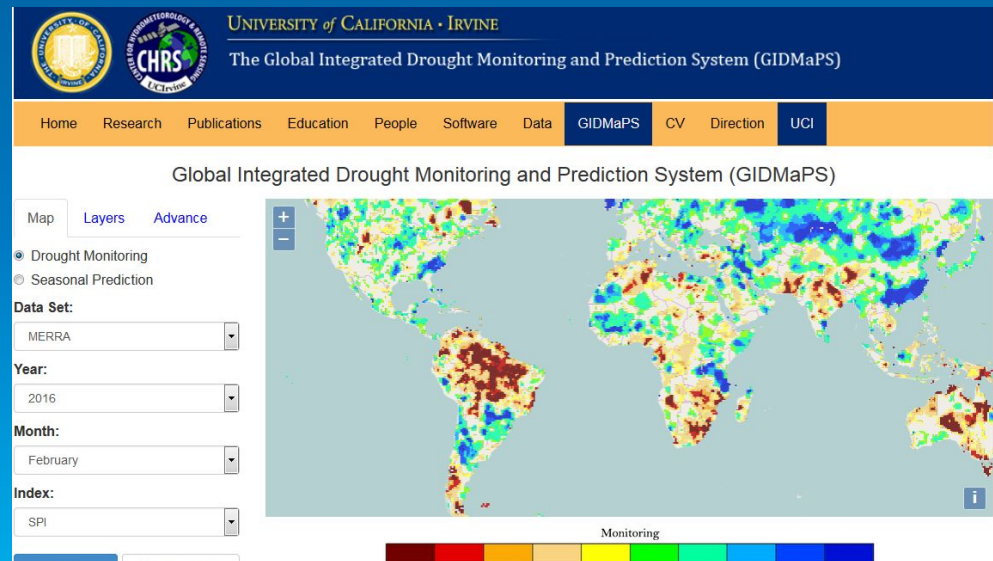
South India Flood – 2015 Northeast Monsoon

Half Hourly GPM Precipitation, 4:30pm Nov. 8 – 4:00am November 9



GES DISC Hydrology Data for Drought Systems

- GES DISC hydrology data are widely used in GIS communities
- These data used in this UC Irvine's drought portal are archived in GES DISC:
 - MERRA
 - GLDAS
 - GCPC
 - NLDAS



Picture screen-copied from <http://drought.eng.uci.edu/>

Access GES DISC Hydrology Data

- All GES DISC hydrology data accessible online through interoperable services, such as OPeNDAP and OGC WCS/WMS data servers.
- The Giovanni system is an easy online visualization, analysis, and access portal.

<http://giovanni.gsfc.nasa.gov/giovanni/>

- A subset of Giovanni served parameters

GIOVANNI The Bridge Between Data and Science v 4.19 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

Access and distribution of Globally-merged, full-resolution (~4 km) IR data from GES DISC... [1 of 2 messages] [Read More](#)

Select Plot

☒ Maps: Time Averaged Map ☐ Comparisons: Select... ☐ Time Series: Select... ☐ Vertical: Select... ☐ Miscellaneous: Select...

Select Date Range (UTC)

YYYY-MM-DD HH:mm to - - : : Valid Range: 1948-01-01 to 2016-05-25

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North
-180, -90, 180, 90

Select Variables

► Disciplines
► Measurements
► Platform / Instrument
► Spatial Resolutions
► Temporal Resolutions
► Wavelengths
► Depths
► Special Features
► Portal

Number of matching Variables: 0 of 1397 Total Variable(s) included in Plot: 0

Keyword:

▼ Measurements

<input type="checkbox"/> Air Pressure (27)	<input type="checkbox"/> Precipitation (93)
<input type="checkbox"/> Air Temperature (30)	<input type="checkbox"/> Quality Info (1)
<input type="checkbox"/> Albedo (8)	<input type="checkbox"/> Radiation, Net (49)
<input type="checkbox"/> Atmospheric Moisture (45)	<input type="checkbox"/> Reflectivity (3)
<input type="checkbox"/> Canopy Water Storage (3)	<input type="checkbox"/> Runoff (48)
<input type="checkbox"/> Cloud Fraction (1)	<input type="checkbox"/> Sensible Heat Flux (5)
<input type="checkbox"/> Cloud Properties (2)	<input type="checkbox"/> Sensible Heat (1)
<input type="checkbox"/> Emissivity (2)	<input type="checkbox"/> Snow/Ice (17)
<input type="checkbox"/> Energy (4)	<input type="checkbox"/> Soil Moisture (170)
<input type="checkbox"/> Erythral UV (4)	<input type="checkbox"/> Soil Temperature (95)
<input type="checkbox"/> Evaporation (33)	<input type="checkbox"/> Surface Runoff (4)
<input type="checkbox"/> Evapotranspiration (34)	<input type="checkbox"/> Surface Temperature (30)
<input type="checkbox"/> Heat Flux (91)	<input type="checkbox"/> UV Exposure (1)
<input type="checkbox"/> Height, Level (2)	<input type="checkbox"/> Vegetation (7)
<input type="checkbox"/> Incident Radiation (63)	<input type="checkbox"/> Water Storage (2)
<input type="checkbox"/> Irradiance (6)	<input type="checkbox"/> Wind Stress Direction (1)
<input type="checkbox"/> Latent Heat Flux (4)	<input type="checkbox"/> Wind Stress Magnitude (2)
<input type="checkbox"/> Latent Heat (1)	<input type="checkbox"/> Wind (37)
<input type="checkbox"/> OLR (10)	

Summary and Future Directions

- GES DISC's multi-spatiotemporal hydrology data are valuable in drought and flood applications.
- The data can be easily visualized and analyzed in ArcGIS.
- The latest ArcGIS analysis and visualization capabilities such as Big Data Store, GeoEvent, and AGOL will make GES DISC data be more efficiently explored.